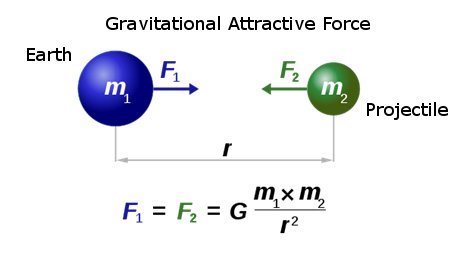
**Projectile Motion Simulation Lab**

Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ partner \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Read the background information on the effect of mass on the trajectory of a projectile and the effect of air resistance on this path:

**Adapted from: Uteach. University of Texas at Austin.** [**https://outreach.uteach.utexas.edu/search/node/?sq=projectile%20motion**](https://outreach.uteach.utexas.edu/search/node/?sq=projectile%20motion)

 “The path taken by a projectile depends only on initial velocity, initial displacement and a constant acceleration due to gravity; the mass of a projectile has no impact on its trajectory. This stems further from the approximation of gravitational attraction between an object and the earth; the force of attraction is proportional to the product of the masses of the two objects divided by the square of the distance between each center of mass. Since the distance between the centers of mass closely approximates the radius of the earth, this gravitational force may be approximated by the mass of the projectile multiplied by a constant acceleration. The formula for the force of attraction between the projectile and the earth is derived from Newton’s Law of Universal Gravitation shown above.  
Gravitational attraction occurs between the Earth and any object.  
The acceleration experienced by the Earth towards projectiles is negligible.

While projectile motion functions well under the circumstances for which it was designed, objects in the environment are not all bowling balls and cannon balls, thus many measurements of time an object remains in the air and the distance travelled will deviate from the predictions of projectile motion. This deviation is largely due to **air resistance**, or more formally fluid friction.

The movement of air varies at a steady rate governed by the forces acting on it; this follows the definition of a fluid. The primary variation between liquid and gas fluids is their density, however all principles of fluid movement apply to both liquids and gases. In simplified terms, any object moving through air must force the air in front of the object to move out of the way. Following Newton’s third law, the force the object exerts on the air is equal and opposite to the force the air exerts on the object. The net force between the object and the air is greatly affected by the surrounding **air pressure**, the **geometry** and **orientation** of the object, and the **velocity** of the object.” [Bold face added for emphasis]

**Key Terms**

* **Projectile** = an object which experiences only the force of gravity
* **Projectile Motion** = the motion of a projectile, governed only by initial position, initial velocity and gravity acting on the projectile
* **Air Pressure** = the omnidirectional force exerted by air on itself and surrounding objects due to gravity and gas molecule collisions
* **Air Resistance** **(drag)** = the force air exerts on any object moving through it due to collisions with the object and surrounding air pressure
* **Drag Coefficient =** the ratio of drag on a moving body to the product of the velocity and surface area of an object
* **Lift –** Upward acting force on a aircraft wing or “airfoil”

***Given the opportunity, how could you design the perfect projectile?***

***What forces are on the projectile after you release it?***

***What is the shape of the path of the projectile?***

Find a partner and line up facing the back of the room.

Mr. Alpert will give you a single piece of paper.

Form a projectile that you think will travel the farthest

Show your projectile to the group and guess which one will travel the length of the room.

Each group (one at a time) will throw their projectile.

One person in each group will retrieve the projectile and then throw it out.

***Note the shape of the projectile which went the farthest:***

***How did you decide on the shape that you made?***

***What was the difference between the air resistance of a paper airplane and a paper ball?***

***What are the forces on a paper ball?***

***On a paper airplane?***

In last night’s homework, you calculated the maximum height and the range of a number of scenarios for projectiles launched at 18 meters per second.

***Which angle had the highest maximum height?***

***Which angle had the longest range?***

***Which angle produced the longest flight time?***

***Which two angles had the same range? Were their flight times different? Why do you think this was?***

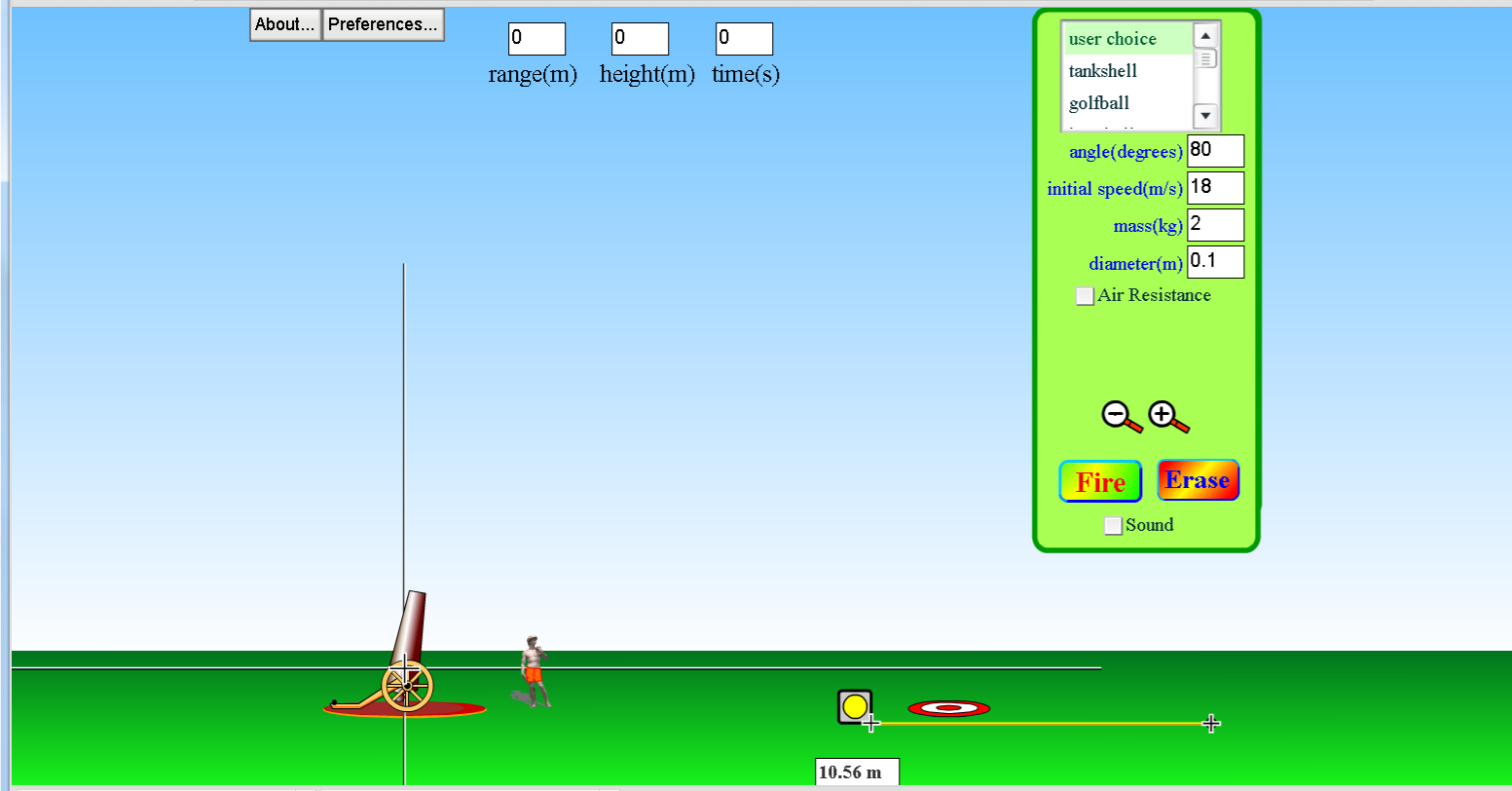
You are to now choose a partner and retrieve a laptop.

Navigate to the Phet projectile motion site: <http://phet.colorado.edu/en/simulation/projectile-motion>

Once the file opens, hit “download”

The program will load as a Java animation file in the lower left corner of your screen.

Once it has loaded, click on it. You will see a screen similar to the one below:



This simulation allows you to choose an object to launch at a given angle and a given velocity. For our purposes we will fix the velocity at 18 m/second as you did in your homework.

Note that the height given is really the height of the canon above or below the surface of the earth. It is not the maximum height of the projectile.

The simulation also allows you to choose your projectile from the following list:

Tank shell, Golf ball, Baseball, Bowling ball, Football, Pumpkin, Adult human, Piano, Buick

***Which objects do you think will be aerodynamic?***

***Why?***

***Which objects do you think would cause the most air turbulence?***

***Why did you select the objects you did?***

The simulation also allows you to turn air resistance on and off.

You are to create a data table with the following information:

Name of object

Angle of launch (30, 45, 60 and 75 degrees)

Duration of flight in seconds

Range

You are to have two columns, one for the flight path without friction and the other with friction.

In a separate table, you are to arrange the nine objects from the shortest range to the longest range at 45 degrees only. You may elect to investigate whether this order repeats itself for other angles for extra credit.

You and your partner are to create one lab report as follows

1. Summary of background information on air resistance, including an investigation into “Bernoulli’s Principal” and “air flow and turbulence around a projectile.”
2. Answers to all of the italicized questions in the body of this lab (they appear in red).
3. Data tables as described above.
4. Answers to the wrap-up questions noted below. You must reflect the questions in your answers.
5. Attach your homework calculations to this report.

**Wrap up Questions**

1. ***Did your calculations for range agree with the Phet calculations without air resistance? If not, why do you think this occurred?***
2. ***What conclusions could you draw about the shape of the projectile and its effect on the range at 45 degrees?***
3. ***Were any of the projectiles aerodynamic? Was this reflected in their range?***
4. ***What was the effect of air resistance on the duration of the flight?***
5. ***Why was mass not a factor in the trajectory and range?***
6. ***What factors affect the amount of air resistance that a projectile undergoes?***
7. ***Why is a projectile defined as an object that is under the influence of gravity alone?***